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BOOK REVIEWS

Number Theory and Physics (Springer Proceedings in Physics, Vol 47)
Proceedings of the Winter School, Les Houches, France, March 7–16, 1989
edited by J-M Luck, P Moussa and M Waldschmidt
Springer-Verlag : Berlin-Heidelberg-New York-London-Paris-Tokyo-Hong Kong, 1990
xiii + 311 pages, 45 figures; price : DM 99,00 (Hard cover); ISBN 3-540-52129-1

The interplay of Physics and Mathematics has been the backbone of development of Physics for more than two centuries. Almost all branches of Mathematics has found application in physics. But there are still some mathematical branches which seemed to be so abstract that scientific community usually considers them to fall purely under abstract mathematics. Number theory is one of the branches of mathematics which seems to fall under this category. Nevertheless, throughout history one can easily search out numerous unexpected relationship of number theory and physics and in recent developments, it can be seen that theoretical physics have involved more and more questions related to number theory and that too, in an increasingly direct way. Several theoretical physicists have experience these developments and have realised that it would be worthwhile to have direct face to face interaction with mathematicians working in number theory. With this idea a workshop was held at the centre de Physique, Les Houches, France from March 7-16, 1989. The book under review is the proceedings of this workshop.

The book contains 32 articles written by different authors and is divided into 5 parts. Each part has some broad heading under which the articles are arranged. Under each head, the articles are arranged as separate papers and as a result, they lack cohesion. But most of the individual articles, although very concise, are full of modern and latest thinking in the subject. Obviously to follow these articles one needs great deal of mathematical background coupled with fair knowledge of the physics of the problem in which the application is made. To give proper justice to this beautiful book, it is better to give a chapterwise review.

The first chapter deals with the conformally invariant field theories, integrability and quantum groups. Conformal Field Theory is believed to be of basic interest both in particle physics and statistical mechanics. The classical status of strong theory are in one to one correspondence with conformal field theories in two dimensions and any statistical system with a second order phase transition is scale, translationally and rotationally invariant at its critical points which is therefore, described by a Conformal Field Theory. This part of the

book consists of 6 articles dealing with various aspects of the Conformal Field theory. Many of the aspects of this part are very concise and need more elaboration.

Recently, the discovery of an Al-based metallic phase with long range orientational order and no translational symmetry, has arisen considerable attention in the scientific community. In these materials, electrons diffracts like a single crystal and yet they show icosahedral symmetry which is not compatible with any periodic order. Although several tentative explanation such as icosahedral glasses were given first, it now seems clear that right approach refers to quasiperiodic ordering and quasiperiodic structure. Attempts have already been made to present models mathematically to explain how ordering can be thought in quasicrystals and related geometrical structures. A good example of this type of quasiperiodic model is the 3D Penrose tiling. Part II of this book deals with these quasicrystals and related geometrical structure. It has altogether 6 articles which mainly consider quasiperiodic structures obtained by several different methods of which Katz article is of special interest. Katz in his article, gives a short account of some mathematical problems related to the structure determination of icosahedral quasicrystals. It is shown that a natural requirement on the geometry of the so called atomic surfaces, leads in a straight forward way to the study of their homology classes and that the corresponding constraints of the density of the quasicrystals are compatible with experimental results. The article by Verger-Gaugry gives a method based on the projection method to calculate the 6D atomic surfaces associated with the given structure.

Part III deals with spectral problems of quasicrystals and other almost periodic structures. This part contains articles with many interesting problems. The spectral problems include the study of some almost periodic systems including the Thue-Morse potential. A fine article discusses Quantum Hall effects with competing periods. It is shown how the Schrödinger equation for an electron in a two dimensional periodic potential and a strong magnetic field can be reduced to a one dimensional probe, in a potential with two different periods. One common thing in these articles is that the spectrum forms a cantor set. One of the articles describes automata in one and two dimensional physics showing substitutions in one dimensional automata produce fractals while in two dimension it gives a regular Robinson tiling.

Part IV contains 5 articles on some dynamical and stochastic systems. The articles discuss many interesting subjects such as nonlinear evolution with travelling waves in irregular filament growth and polymers on disordered trees and branching random walks. Another article discusses Hannay anglus as a means of measuring anholonomy of clasical mechanics close to Berry phase in quantum mechanics.

Last part discusses some further arithmetical problems and their relationship to physics.

Although the book's title indicates a relation between mathematics and physics, stress has been given more on mathematics than physics. The articles are more interested in deriving theorems than underlying physics in it. There is however, exception in the chapters dealing

with quasicrystal whose physics have been elaborately discussed. The book in general, is of very high standard and suitable only for research workers engaged in a serious mathematical and theoretical physics. Some experimentalists, however, are well equipped now a days with mathematics. This book can be a good source of information and reference to them also.

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Polymers for Lightwave and Integrated Optics : Technology and Applications
(Optical Engineering Series, Vol 32)
edited by Lawrence A Hornak

Marcel Dekker : New York–Basel–Hong Kong, 1992
768 pages; illustrated ; price : $ 150.00 (Hard cover) ; ISBN 0–8247–8697–1

Optical engineering is now established as an important discipline in its own right. Use of new polymeric materials for light wave guide and integrated optics is an area of rapid expansion in optical engineering. The present volume from Marcel Dekker Inc is a timely publication in this regard. This is not a research monograph and is principally meant for practicing scientists and engineers.

The volume consists of two parts, Part I comprises ten chapters on passive optical polymers and their applications whereas nonlinear optical polymers and their applications are treated in fourteen chapters of Part II.

Polymer fibres which transmit optical signals, have many advantages over glass fibres. In the first chapter, Kaino discusses present application status of polymer optical fibres and the possibility of new polymer materials in optical signal transmission and in optoelectronic communication.

Effect of tap, T-coupler and star coupler on the transmission properties of PMMA optical fibres and their application as temperature and pH sensors are discussed in the next chapter by Theis and his group.

Graded index (GRIN) materials display more novel and useful optical properties than materials of constant refractive index. The advantages of such GRIN polymeric materials in telecommunication have been discussed in Chapter III by Koike.

In the following chapter, Franke has discussed several types of radiation induced patterning of PMMA based lightguides : photo-polymerization, photo-induced self-condensation, photo-induced adhesion patterning and ion implantation. Monroe and Smothers in Chapter V, have reviewed the photo-polymers for refractive index imaging and production of holographic mirrors with good reflection efficiency.

Micro-optical grating elements have bright prospects for new applications including spatial frequency filter for charge-coupled device cameras and liquid-crystal-display television system. This topic has been covered by Kawatsuki and Uetsuki. Synthesis and application of polysilyne for optical waveguide application has been discussed by Weidman *et al* in Chapter VII. Franke in the following chapter, has brought out the usefulness of polyimide as lightguide material as it can withstand processing temperature upto 300°C and still form low loss lightguide and can be patterned.

Information transmission and processing systems require advanced interconnect technology to resolve bottle-necks resulting from high circuit density, multiple pinouts and high data transmission and processing rates. Interconnection polymers have been treated elegantly by Booth in Chapter IX and by Hartman in Chapter X.

Norwood *et al* in Chapter XI, discuss the poling of polymers incorporating nonlinear optical chromophores which results in noncentrosymmetric thin film structures, useful for integrated electro-optics applications whereas Singer describes the physical origin of the optical nonlinearity in molecular polymeric systems with particular emphasis on second order processes in poled polymeric systems in Chapter XII. Electrochroism of dye-polymer mixture and various other guest-host systems and second order nonlinearities in these materials have been exposed by Pantalis and Hill in the following chapter. Progress in the field of devices realised in nonlinear optical side-chain polymers incorporating nonlinear moieties as pendant group has been reviewed by Vorst *et al* in Chapter XIV. Promise of these materials in optical information technology has been brought out. Application for polymer electro-optic devices in the form of discrete, high speed optical components integrated with power and logic driving electronic circuits has been elaborated by Holland in Chapter XV. The marriage of polymer optics and silicon electronics will expand the capabilities of the devices to new height. A thorough discussion of the use of polymers in VLSI multichip modules is presented by Lytel *et al* in Chapter XVI. In the following chapter, Kowel and Eldering review the state of development of nonlinear polymer thin film systems for use as electro-optic modulators and present an in-depth discussion of the relevant scientific and technological issues.

In contrast to the considerable progress realised with second-order optical processes, the microscopic many electron description for nonresonant third-order optical processes such as third-harmonic generation, degenerate four-wave-mixing and optical Kerr effect in conjugated structures, is relatively new and these constitute the topic of the following four chapters. Helfin and Garito review the results of theoretical and experimental studies of the microscopic origin of non-resonant third order optical processes in conjugated linear-chains and show that electron correlation effects determine the virtual excitation processes and third-order nonlinear properties. Kobayashi presents elaborate experimental studies of third order nonlinear processes and ultrafast dynamics of optical nonlinearity due to relaxation of excitations in polymers. Interferometric studies of nonlinear refractive indices, femto-second pump-probe experiments and degenerate four-wave-mixing studies have been described. Kajzar *et al* emphasise the experimental conditions in which large third order nonlinearities are

demonstrated by organic materials. They consider two frequency domanins : the transparency domain where coherent effects dominate and the absorption domain where nonlinearities are large due to large excited state population.

Kaino and Kurihara discuss processable rigid π-conjugated organic materials which show large third order susceptibility originating from certain dominant resonant levels present. They emphasize that an intramolecular charge transfer derived from substituted donors and acceptors, contributes to the increase in the third order nonlinearity and intramolecular charge transfer dye-attached polymer systems show high $\chi^{(3)}$ value.

One dimensional confinement of electrons leads to many unique and technologically important properties. Conjugated polymers such as polydiacetylene is one such quantum wire material with extremely large $\chi^{(3)}$ value. In Chapter XXII, Thakur describes all-optical phase modulation in such polydiacetylene waveguides. Conventional electronic computing is expected to be replaced by photonics based on all optical data processing with photons. Such optical computers will be characterised by data mass store with storage capacity in the order of terabytes, data transfer rate of gigabyte per second and random access time in micro or nanoseconds. The technology gap for such system is paramount. In Chapter XXIII, Driemeier and Lechner review the prospects and possibilities of holographic memories using organic storage materials to meet the challenge. In the concluding chapter, Itoh and Tani have focussed on the relationship between material structure and persistent hole burning in relevance to the development of high density optical memory.

Polymeric optical materials have the potential to coexist with inorganic optical and electronic materials thus allowing full integration of optics and electronics in component and system levels. This is a very interdisciplinary field covering chemistry, physics, material science and electronics.

In this 750 page book, the authors give an overview of a large field and cover many important features regarding application of polymer materials for light waveguide and integrated optics. The level of presentation is such that it can serve as an introduction for readers coming from wide range of backgrounds. The citation of a large number of references at the end of each chapter is an added feature which will be useful to practicing technologists and researchers. Optical effects which can lead to the control of light by electric field, light by light and electric field by light, have the potential in optical signal processing and optical computing. Indeed, many may agree with Kobayashi that 'the coming century is to be the *century of light* and the technology of light will lead to the realisation of an *Optopia.*

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Organic Photoreceptors for Imaging Systems (Optical Engineering Series/39)
edited by Paul M Borsenberger and David S Weiss
Marcle Dekker : New York, 1993
xvi+ 447 pages. illustrated ; price : $ 135.00 (bound) : ISBN 0–8247–8926–1

Xerography is certainly one of the leading technological innovations of this century. At present this is the dominant method of non-impact printing all over the world and is used virtually in all copiers in the market. Of the many technologies that have led to the development of xerography, photoreceptor technologies have played a major role. Organic materials as photoreceptor are particularly well-suited for all the requirements of xerographic process and has been a subject of extensive research in recent years. The topic being a part of rapid expansion of optical engineering, publishing a review of practical aspects of developments in the form of 'Organic photoreceptors for imaging systems', Marcel Dekker, Inc has done a laudable job for the community.

The book comprises 13 chapters beginning with an introduction on early developments of xerography and different electrophotographic processes with special emphasis on the key role of organic photoreceptors. Since the early days of xerography, different types of materials have been used as photoreceptors but chalcogenide glasses, organic materials and amorphous silicon are mostly used. Chapter 2 is devoted to the preparation, advantages, cost and limitations of these materials and organic materials seemed to be the preferred one over others on all counts. For creating electrostatic latent image in xerography, a previously charged photoreceptor is exposed to an imagewise pattern of radiation which selectively dissipates the surface potential in exposed regions. In practice, the surface potential and persistence of the image for a considerable time are dependent mainly on charge acceptance and the rate of dark discharge of photoreceptor. The different models for charge acceptance and discharge along with some experimental results are the main constituents of Chapter 3.

Photoinduced discharge, arising out of continuous or flash exposures is associated with latent image formation. In continuous exposure category mainly two types of models on emission– and space-charge-limited currents are used. Along with these models other factors in flash exposures, significance of trapping on photoinduced discharge recombination of electron and a hole and the idea of sensitometry have been discussed nicely in Chapter 4. Chapter 5 reviews the theories proposed to describe photogeneration in organic solids. Authors have elegantly discussed the surface enhanced exciton dissociation model and its limitations like non-inclusion of photon energy and temperature dependencies of photo-generation process. One of the models based on exciton-exciton annihilation involves tunnel ionisation and small polaron transitions. But the widely used ones are geminate recombination and surface enhanced exciton dissociation models.

More or less exhaustive review of literature results of photogeneration in a series of pthalocyanines, polyarylenes polymers and other materials of interest have been accommodated in Chapter 6. In most of the materials, the photogeneration efficiencies increase with increasing temperature. Only for pthalocyanines, the efficiencies are independant of wavelength.

In xerography, the photogeneration of free carriers in photoreceptors occur in the generation layer or at the interface between generation and transport layers of dual layer arrangement. Mobility, a fundamental requirement of transport layer, of free carriers should be such that the charge can transmit the layer thickness in a time that is short compared to the time between the exposure and image development steps. Polymers are widely used for tranport layers. The authors in Chapter 7, discuss briefly the theories proposed to describe charge transport in polymers based on Poole-Frenkel formatism, Bässler formalism and their limitations. Of the two recent ones, lattice gas and percolation models, most studies of doped polymers have been described by the former one.

A common feature for polymers and organic glasses is that the mobilities are very low. Chapter 8 reviews the charge transport in above materials highlighting the common features like unipolar transport processes and the mobilities that are temperature and field dependent. Experimental techniques for measuring the two key parameters like free carriers photogeneration quantum efficiency and charge transport mobility are of paramount importance to xerography. In Chapter 9, the authors describe the different methods for measuring these two parameters *viz*. transient photocurrent measurement, photoinduced discharge measurements, photoacoustical measurements, field-enhanced fluorescence quenching method and deconvolution techniques.

Chapter 10 constitutes the different methods of single-layer or dual-layer photoreceptor preparation and their physical and chemical characterisation. Chapter 11 reviews the sensitometry, structure and composition of azo pigments, molecular complexes, perylene pigments and other materials of interest. The comparison of single and dual-layer photoreceptor in respect of cost, sensitivity, rate of dark discharge and cyclic stability is a very useful one.

Owing to the complexity of physical and chemical interaction, between the photoreceptor and the various xerographic process elements, complete understanding of the mechanism of photoreceptor fatigue for commercial application is of considerable importance. Chapter 12 deals with the possible elements which may contribute to fatigue. The Chapter 13 gives an useful summary and the requirements of future generation copiers. A major requirement for those type of copiers is certainly the materials with improved fatigue resistance, particularly with respect to trapping and corona- and radiation-induced effects, improved wear resistance in conjunction with emphasis on cost reduction.

The present reviewer strongly feels that this book will be an useful source book to the scientists working in the area of xerography for quite some time to come.

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